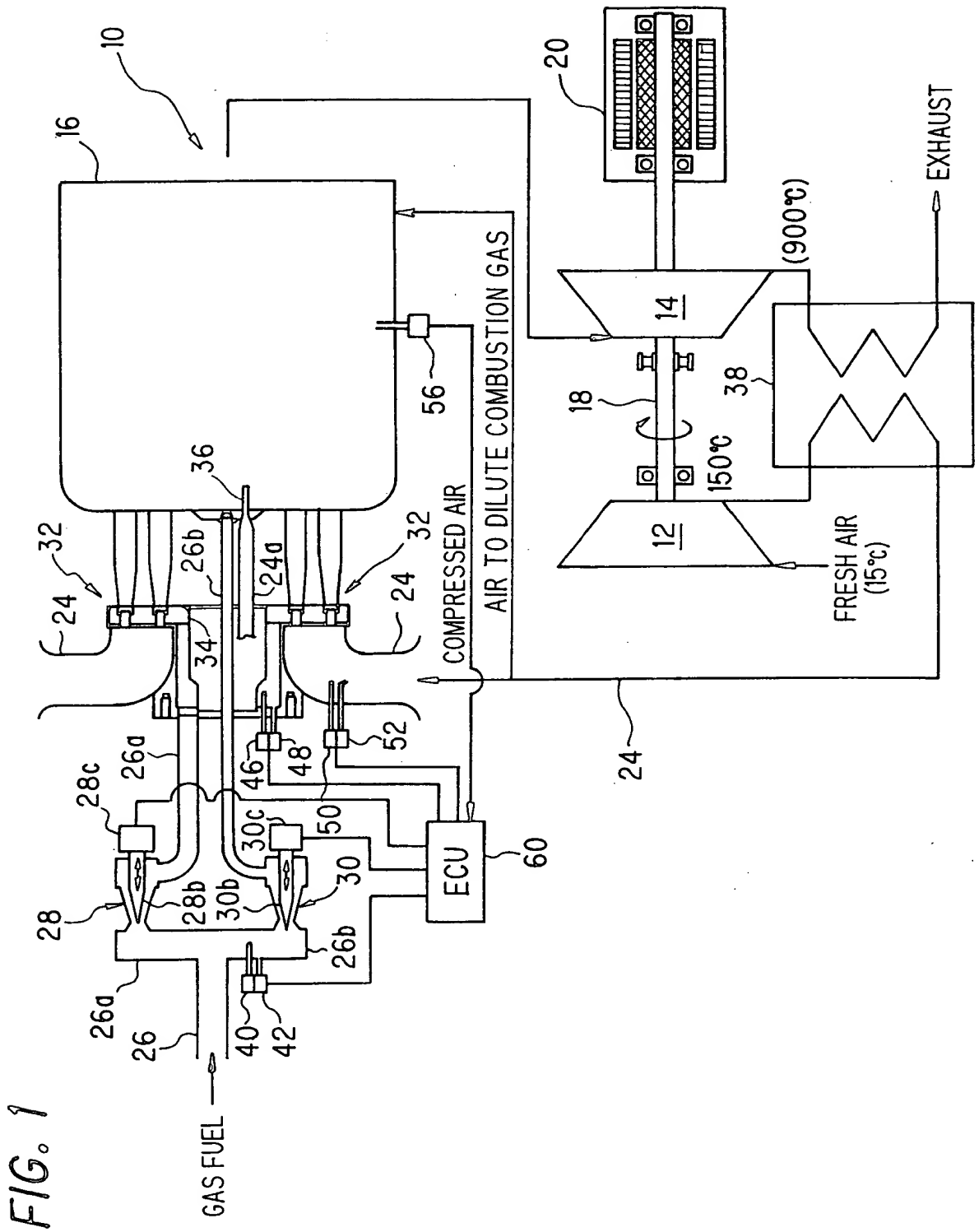

10
16
20
EXHAUST
(900°C)
14
18
38
150°C
12
FRESH AIR
(15°C)
AIR TO DILUTE COMBUSTION GAS
COMPRESSED AIR
56
36
32
24
26b
24a
34
52
48
46
50
28c
26a
30c
28
28b
30b
30
26b
26a
26
40
42
GAS FUEL
ECU
60

FIG. 1

FIG. 2

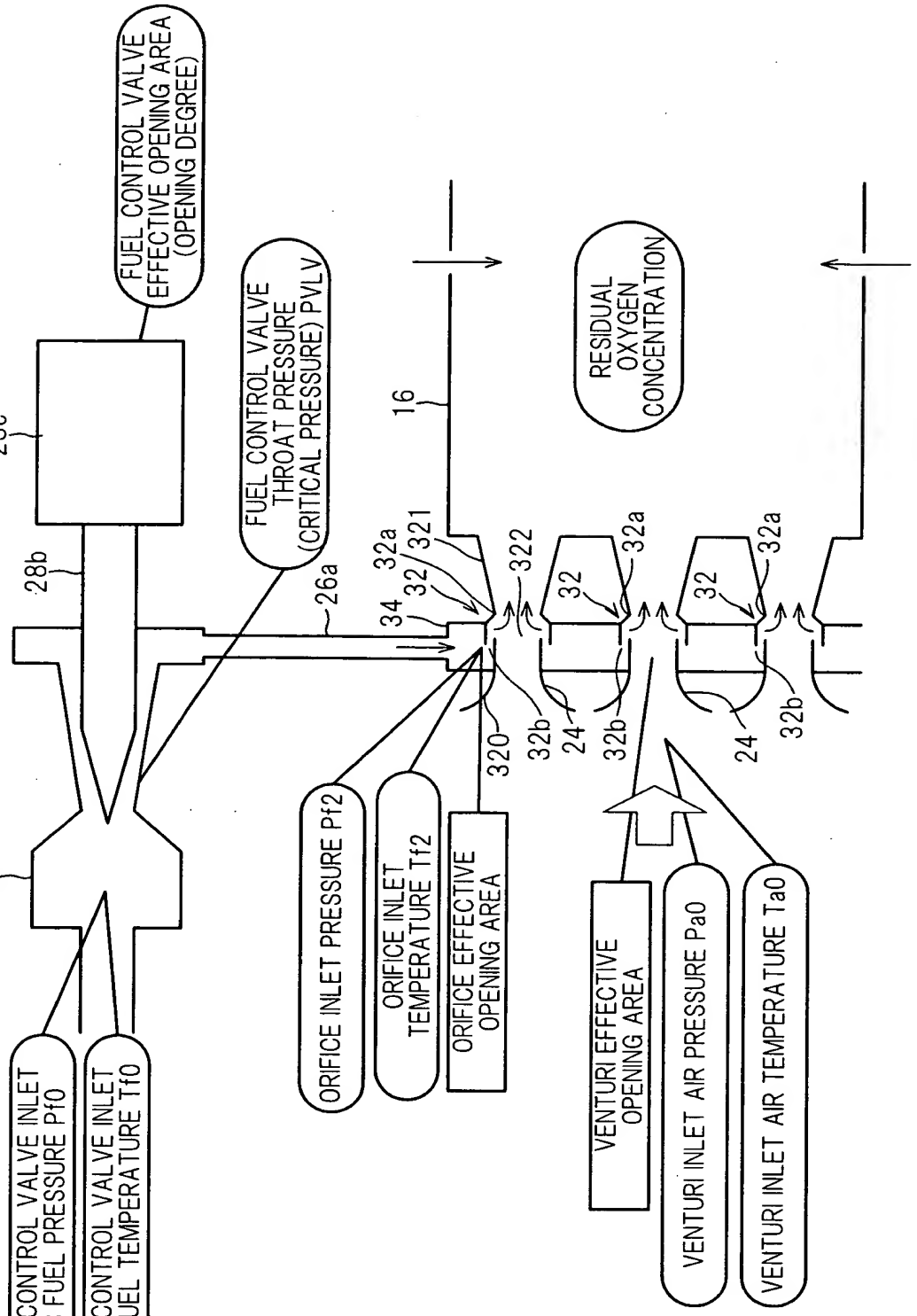

FUEL CONTROL VALVE INLET GAS FUEL PRESSURE Pf0
FUEL CONTROL VALVE INLET GAS FUEL TEMPERATURE Tf0
28a
28b
28c
FUEL CONTROL VALVE EFFECTIVE OPENING AREA (OPENING DEGREE)
FUEL CONTROL VALVE THROAT PRESSURE (CRITICAL PRESSURE) PVLV
26a
16
ORIFICE INLET PRESSURE Pf2
ORIFICE INLET TEMPERATURE Tf2
ORIFICE EFFECTIVE OPENING AREA
320
321
322
32a
32
34
32b
24
RESIDUAL OXYGEN CONCENTRATION
VENTURI EFFECTIVE OPENING AREA
VENTURI INLET AIR PRESSURE Pa0
VENTURI INLET AIR TEMPERATURE Ta0

FIG. 3

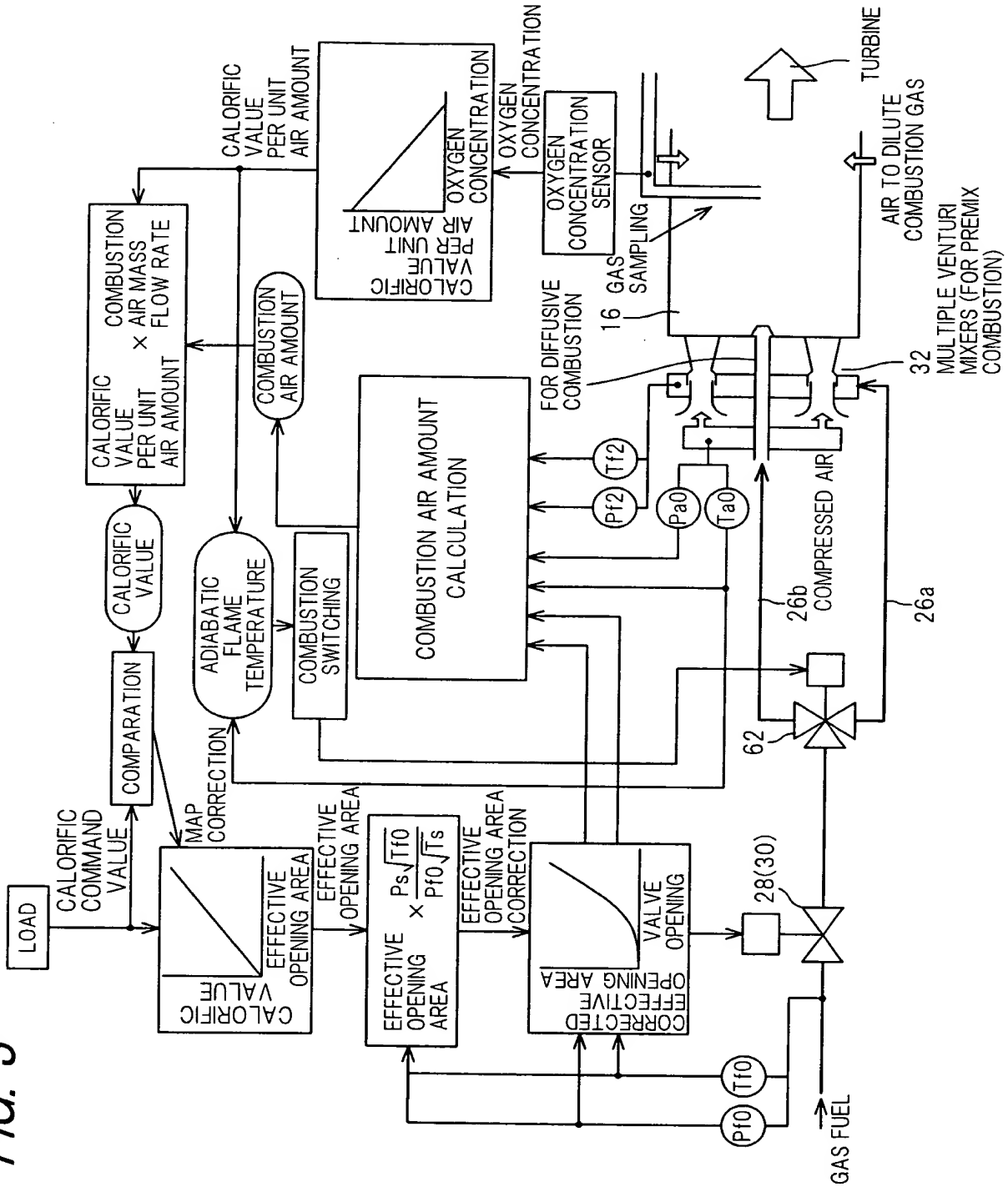

LOAD
CALORIFIC COMMAND VALUE
COMPARATION
CALORIFIC VALUE
CALORIFIC VALUE PER UNIT AIR AMOUNT
COMBUSTION AIR MASS FLOW RATE
ADIABATIC FLAME TEMPERATURE
COMBUSTION SWITCHING
COMBUSTION AIR AMOUNT
COMBUSTION AIR AMOUNT CALCULATION
CALORIFIC VALUE PER UNIT AIR AMOUNT
OXYGEN CONCENTRATION
OXYGEN CONCENTRATION SENSOR
FOR DIFFUSIVE COMBUSTION
16 GAS SAMPLING
TURBINE
AIR TO DILUTE COMBUSTION GAS
32 MULTIPLE VENTURI MIXERS (FOR PREMIX COMBUSTION)
Tf2
Pf2
Pa0
Ta0
COMPRESSED AIR
26b
26a
62
MAP CORRECTION
EFFECTIVE OPENING AREA
CALORIFIC VALUE
EFFECTIVE OPENING AREA
EFFECTIVE OPENING AREA CORRECTION
CORRECTED EFFECTIVE OPENING AREA
VALVE OPENING
28(30)
Tf0
Pf0
GAS FUEL

FIG. 4

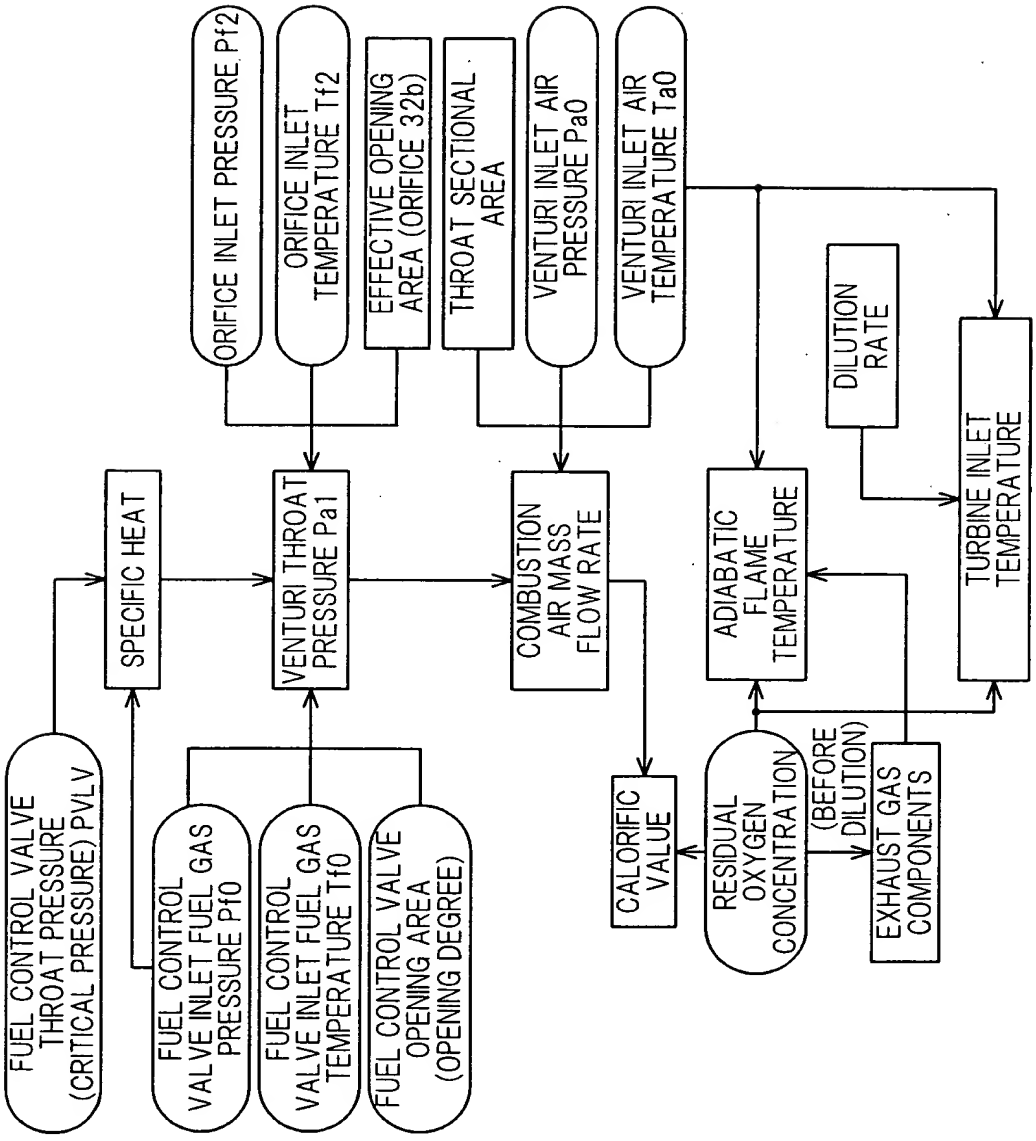

FUEL CONTROL VALVE THROAT PRESSURE (CRITICAL PRESSURE) PVLV
FUEL CONTROL VALVE INLET FUEL GAS PRESSURE Pf0
FUEL CONTROL VALVE INLET FUEL GAS TEMPERATURE Tf0
FUEL CONTROL VALVE OPENING AREA (OPENING DEGREE)
SPECIFIC HEAT
ORIFICE INLET PRESSURE Pf2
ORIFICE INLET TEMPERATURE Tf2
EFFECTIVE OPENING AREA (ORIFICE 32b)
VENTURI THROAT PRESSURE Pa1
THROAT SECTIONAL AREA
VENTURI INLET AIR PRESSURE Pa0
VENTURI INLET AIR TEMPERATURE Ta0
COMBUSTION AIR MASS FLOW RATE
CALORIFIC VALUE
RESIDUAL OXYGEN CONCENTRATION
(BEFORE DILUTION)
EXHAUST GAS COMPONENTS
ADIABATIC FLAME TEMPERATURE
DILUTION RATE
TURBINE INLET TEMPERATURE

FIG. 5

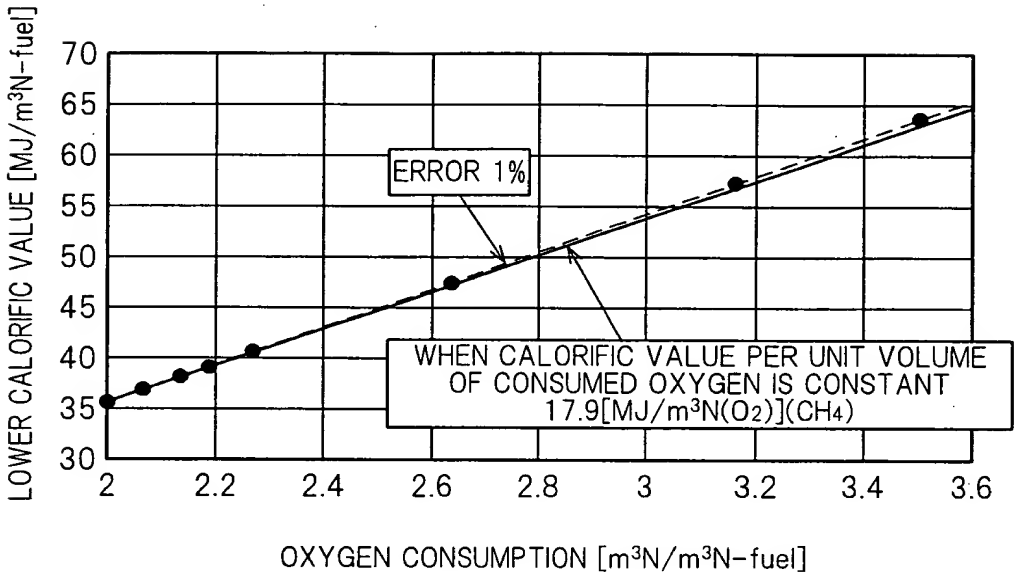

LOWER CALORIFIC VALUE [MJ/m3N-fuel]
70
65
60
55
50
45
40
35
30
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
ERROR 1%
WHEN CALORIFIC VALUE PER UNIT VOLUME OF CONSUMED OXYGEN IS CONSTANT 17.9[MJ/m3N(O2)](CH4)
OXYGEN CONSUMPTION [m3N/m3N-fuel]

FIG. 6

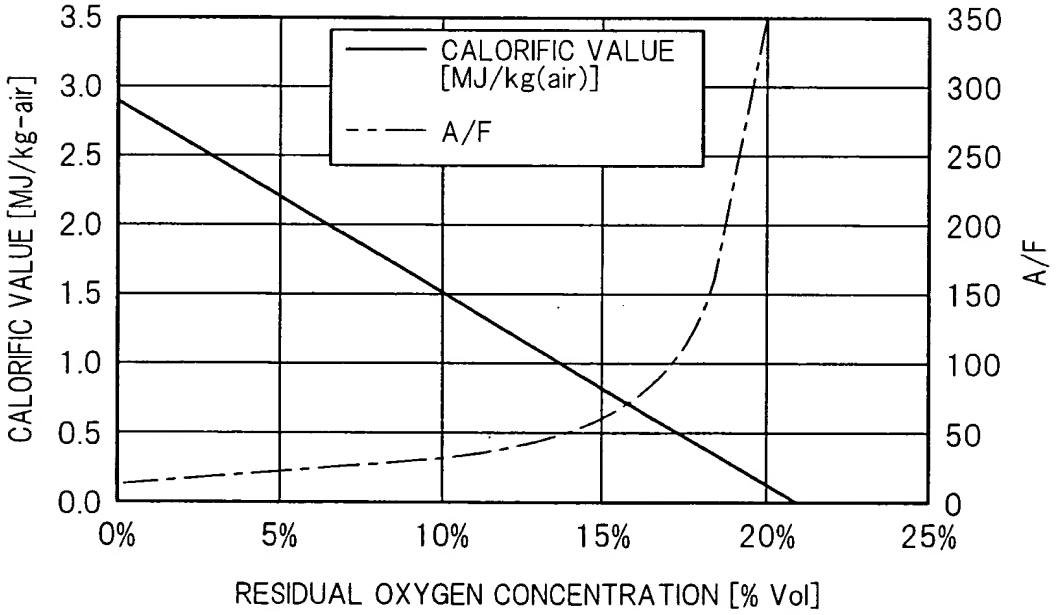
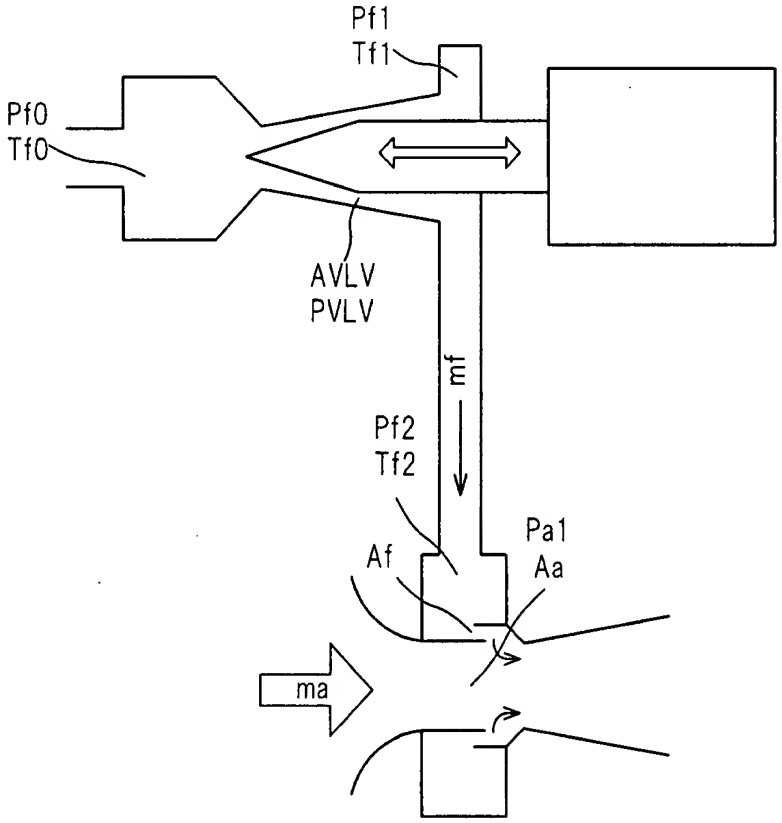

CALORIFIC VALUE [MJ/kg-air]
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
350
300
250
200
150
100
50
0
A/F
CALORIFIC VALUE [MJ/kg(air)]
A/F
0%
5%
10%
15%
20%
25%
RESIDUAL OXYGEN CONCENTRATION [% Vol]

FIG. 7

$$mf = \frac{Pf2Af}{\sqrt{RfTf2}} \sqrt{\frac{2\kappa f}{\kappa f - 1}\left\{\left(\frac{Pa1}{Pf2}\right)^{\frac{2}{\kappa f}} - \left(\frac{Pa1}{Pf2}\right)^{\frac{\kappa f+1}{\kappa f}}\right\}}$$

$$ma = \frac{Pa0Aa}{\sqrt{RaTa0}} \sqrt{\frac{2\kappa a}{\kappa a - 1}\left\{\left(\frac{Pa0}{Pa1}\right)^{\frac{2}{\kappa a}} - \left(\frac{Pa0}{Pa1}\right)^{\frac{\kappa a+1}{\kappa a}}\right\}}$$



Pf0 : FUEL CONTROL VALVE INLET PRESSURE [Pa]
Pf2 : ORIFICE INLET PRESSURE [Pa]
PVLV : FUEL CONTROL VALVE THROAT PRESSURE [Pa]
Pa0 : VENTURI INLET AIR PRESSURE [Pa]
Pa1 : VENTURI THROAT PRESSURE [Pa]
Tf0 : FUEL CONTROL VALVE INLET TEMPERATURE [K]
Tf2 : ORIFICE INLET TEMPERATURE [K]
Ta0 : VENTURI INLET AIR TEMPERATURE [K]

mf : FUEL MASS FLOW RATE [kg/sec]
ma : AIR MASS FLOW RATE [kg/sec]
AVLV : FUEL CONTROL VALVE EFFECTIVE OPENING AREA [m^2]
Af : ORIFICE INLET EFFECTIVE OPENING AREA [m^2]
Aa : VENTURI THROAT EFFECTIVE OPENING AREA [m^2]
Rf : FUEL GAS CONSTANT [kJ/kg K]
Ra : AIR GAS CONSTANT [kJ/kg K]
κf : FUEL GAS SPECIFIC HEAT
κa : AIR SPECIFIC HEAT

FIG. 8

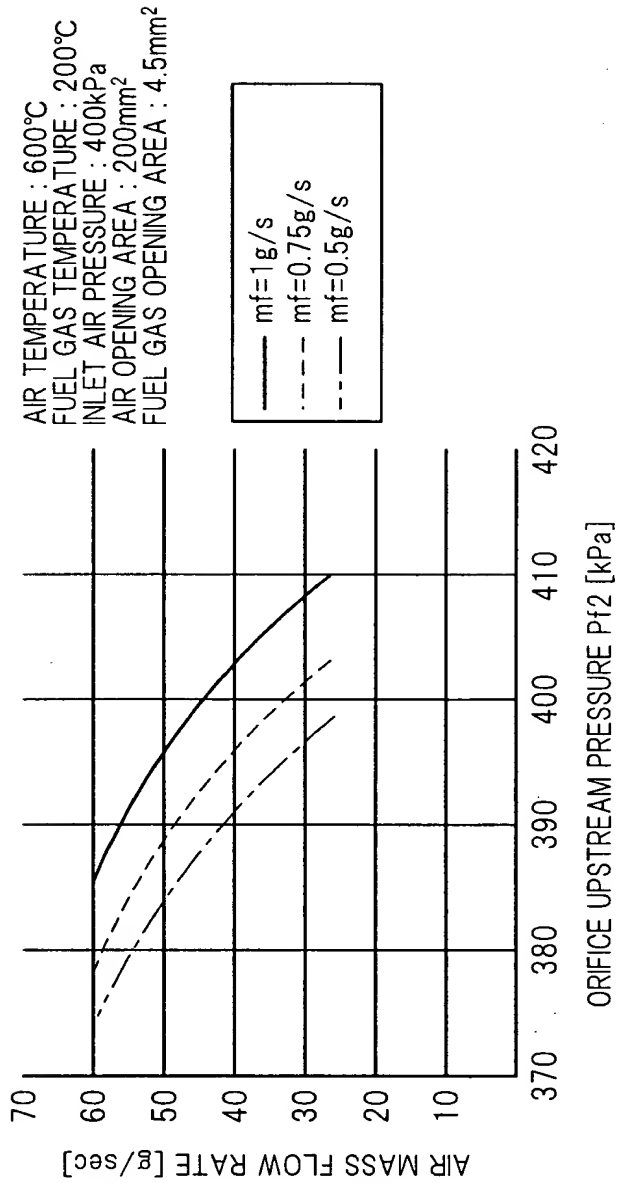

AIR TEMPERATURE : 600°C
FUEL GAS TEMPERATURE : 200°C
INLET AIR PRESSURE : 400kPa
AIR OPENING AREA : 200mm²
FUEL GAS OPENING AREA : 4.5mm²
mf=1g/s
mf=0.75g/s
mf=0.5g/s
AIR MASS FLOW RATE [g/sec]
70
60
50
40
30
20
10
370
380
390
400
410
420
ORIFICE UPSTREAM PRESSURE Pf2 [kPa]

FIG. 9

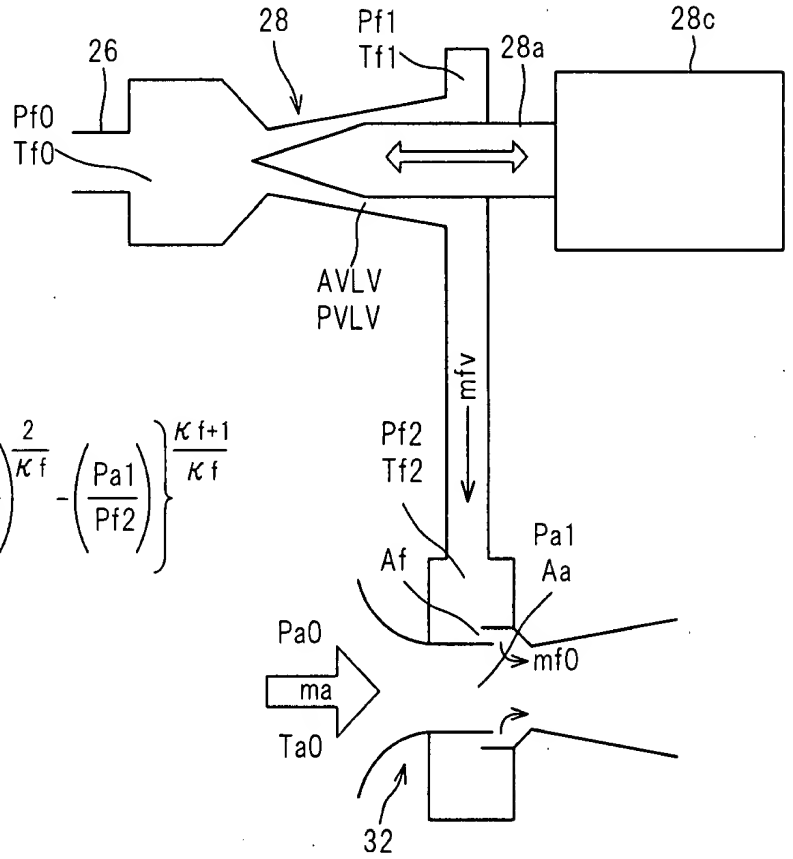
$$mfv = \frac{Pf0AVLV}{\sqrt{RTf0}} M\sqrt{\kappa f}\left(1+\frac{\kappa f-1}{2}M^2\right)^{\frac{\kappa f+1}{2(\kappa f-1)}}$$

$$mf0 = \frac{Pf2Af}{\sqrt{RTf2}}\sqrt{\frac{2\kappa f}{\kappa f-1}\left\{\left(\frac{Pa1}{Pf2}\right)^{\frac{2}{\kappa f}}-\left(\frac{Pa1}{Pf2}\right)^{\frac{\kappa f+1}{\kappa f}}\right\}}$$

SINCE VALVE IS CHOKED-FLOW RATE VALVE, MACH IS 1, THIS YIELDS FOLLOWING

$$=\left\{\frac{Pf0AVLV\sqrt{Tf2}}{\sqrt{Tf0}\,Pf2Af}\sqrt{\kappa f}\left(1+\frac{\kappa f-1}{2}\right)^{\frac{\kappa f+1}{2(\kappa f-1)}}\right\}^2 \frac{\kappa f-1}{2\kappa f}=\left\{\left(\frac{Pa1}{Pf2}\right)^{\frac{2}{\kappa f}}-\left(\frac{Pa1}{Pf2}\right)\right\}^{\frac{\kappa f+1}{\kappa f}}$$

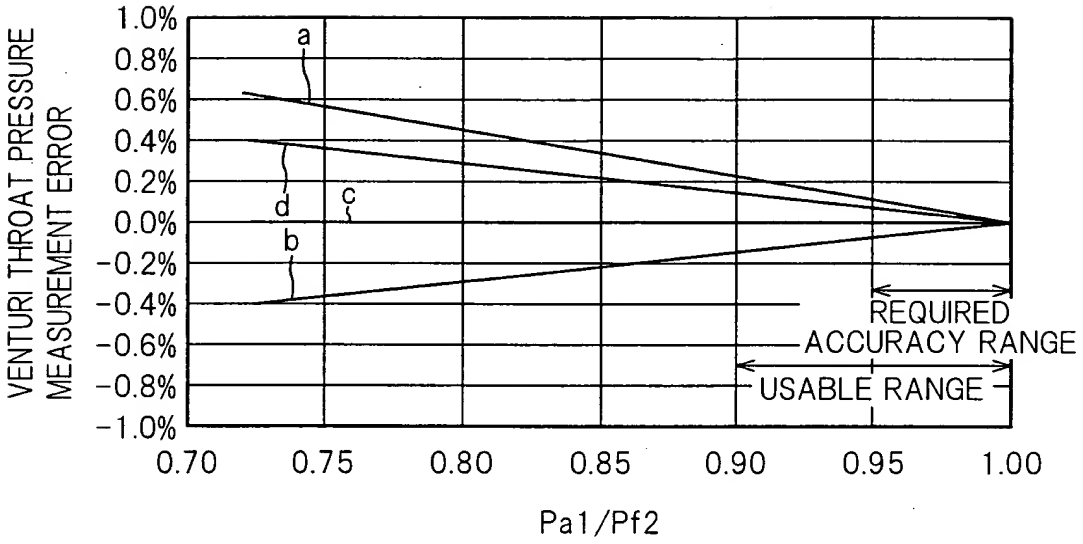
$$ma = \frac{Pa0Aa}{\sqrt{RaTa0}}\sqrt{\frac{2\kappa a}{\kappa a-1}\left\{\left(\frac{Pa0}{Pa1}\right)^{\frac{2}{\kappa a}}-\left(\frac{Pa0}{Pa1}\right)^{\frac{\kappa a+1}{\kappa a}}\right\}}$$



Pf0 : FUEL CONTROL VALVE INLET PRESSURE [Pa]
Pf2 : ORIFICE INLET PRESSURE [Pa]
PVLV : FUEL CONTROL VALVE THROAT PRESSURE [Pa]
Pa0 : VENTURI INLET AIR PRESSURE [Pa]
Pa1 : VENTURI THROAT PRESSURE [Pa]
Tf0 : FUEL CONTROL VALVE INLET TEMPERATURE [K]
Tf2 : ORIFICE INLET TEMPERATURE [K]
Ta0 : VENTURI INLET AIR TEMPERATURE [K]

mf : FUEL MASS FLOW RATE [kg/sec]
ma : AIR MASS FLOW RATE [kg/sec]
AVLV : FUEL CONTROL VALVE EFFECTIVE OPENING AREA [m^2]
Af : ORIFICE INLET EFFECTIVE OPENING AREA [m^2]
Aa : VENTURI THROAT EFFECTIVE OPENING AREA [m^2]
Rf : FUEL GAS CONSTANT [kJ/kg K]
Ra : AIR GAS CONSTANT [kJ/kg K]
κf : FUEL GAS SPECIFIC HEAT
κa : AIR SPECIFIC HEAT

FIG. 10



SAMPLES	SPECIFIC HEAT
a	1.309
b	1.251
c	1.274
d	1.296

FIG. 11

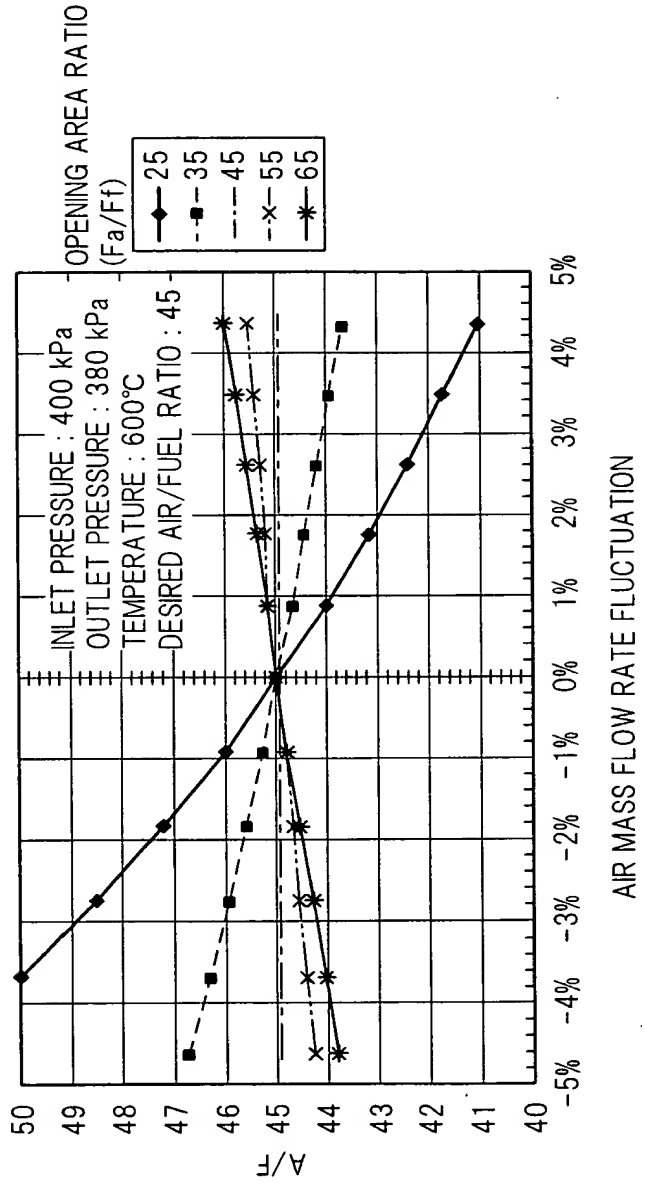

INLET PRESSURE : 400 kPa
OUTLET PRESSURE : 380 kPa
TEMPERATURE : 600°C
DESIRED AIR/FUEL RATIO : 45
OPENING AREA RATIO (Fa/Ff)
25
35
45
55
65
A/F
50
49
48
47
46
45
44
43
42
41
40
-5% -4% -3% -2% -1% 0% 1% 2% 3% 4% 5%
AIR MASS FLOW RATE FLUCTUATION

FIG. 12

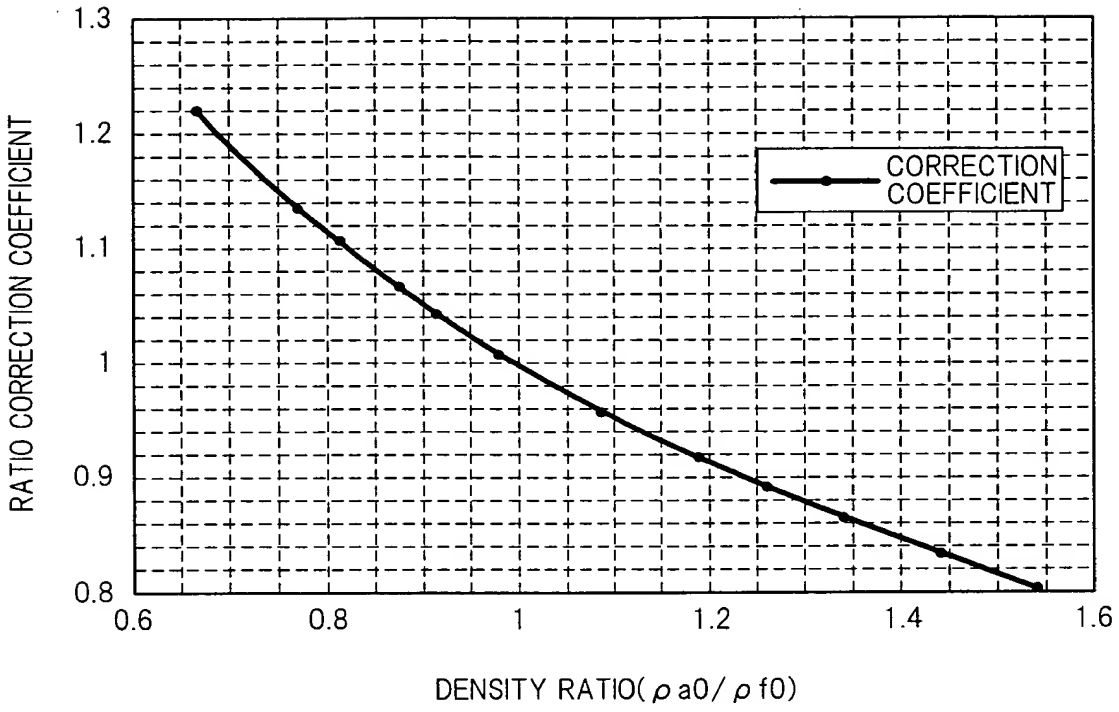
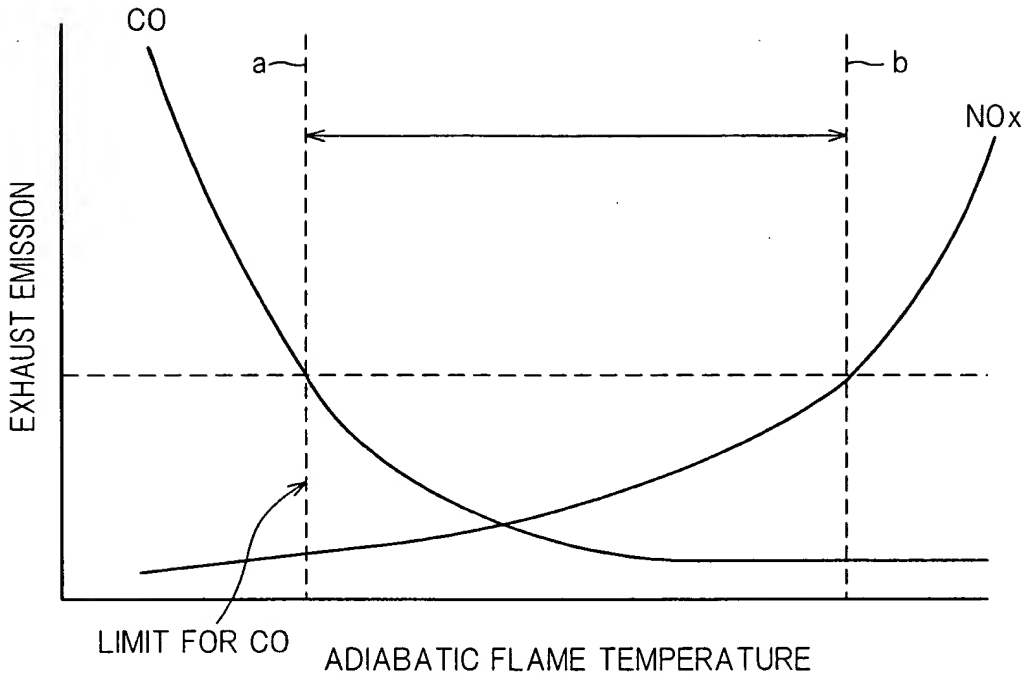

1.3
1.2
1.1
1
0.9
0.8
0.6
0.8
1
1.2
1.4
1.6
RATIO CORRECTION COEFFICIENT
DENSITY RATIO(ρ a0/ ρ f0)
CORRECTION COEFFICIENT

FIG. 13


CO
a
b
NOx
EXHAUST EMISSION
LIMIT FOR CO
ADIABATIC FLAME TEMPERATURE